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EFFECT OF GROWTH RETARDANTS ON MORPHO-PHYSIOLOGICAL PARAMETERS IN COTTON UNDER IRRIGATED CONDITIONS IN COTTON-WHEAT SYSTEM

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SUMMARY

Growth retardant spray (pix and cycocel @ 50 and 100 ppm) on two cotton genotypes reduced the vegetative growth i.e. leaf area (20-25%) and plant height (9-17%) whereas it increased the reproductive growth i.e. boll weight (5-16%), harvest index (8-12%) and seed-cotton yield (4-9%). The net returns of cotton-wheat system increased by 6%. Two sprays at 90 and 120 DAS in cotton reduced the vegetative growth, yield attributes and seed-cotton yield resulting in less net returns (12% reduction) as compared to one spray. Seed-cotton yield, boll weight and harvest index of LHH 144 were significantly higher (4.5%, 15.8% and 17%, respectively) as compared to F 1861. Growth retardants increased the specific leaf weight (70-80%) resulting in higher leaf chlorophyll content (29-69%). This led to higher photosynthesis (20-22%), photosynthetic radiation use efficiency (22%) and photosynthetic water use efficiency (15-32%). It is revealed that application of pix (50 ppm) in cotton at 90 DAS is useful in controlling excessive vegetative growth and enhancing the yield of cotton under irrigated conditions.

***Key words*: Leaf area index, net returns, photosynthesis, seed-cotton yield, wheat yield equivalent**

INTRODUCTION

Cotton is a subtropical, perennial plant with an indeterminate growth habit. Vegetative and reproductive development occurs simultaneously. While vegetative growth is necessary to support reproductive growth, excessive vegetative growth can be detrimental. Under the excessive vegetative growth situations, fruit abortion may be increased, crop maturity may be delayed and all these may lead to low yield. Growth habits of cotton varieties are inconsistent, with many characterized by their tendency for aggressive vegetative growth. The growth habit of these varieties combined with exposure to high availability of nutrients, timely rainfall or irrigation and delayed fruit retention may encourage excessive vegetative growth. Growth retardants have been used to reduce stem elongation and leaf size of cotton (Cathey and Luckett 1980) and increase cotton yield (Singh and Sahay 1989). An attempt has, therefore, been made to study the effect of growth retardants on cotton under irrigated ecosystem for higher productivity of cotton-wheat system.

MATERIALS AND METHODS

A field experiment was conducted at the Main Research Farm of the Project Directorate for Farming Systems Research, Modipuram, Meerut during 2004-05, 2005-06 and 2006-07 with two *hirsutum* cotton genotypes (LHH 144 and F 1861). The plants were grown at a recommended spacing of 67.5 x 30 cm for variety and 67.5 x 60 cm for hybrid. The crop was fertilized with 60 kg nitrogen; 30 kg phosphorous (P_2O_5) and 30 kg potassium (K_2O) / ha. The soil of the experimental site

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was sandy loam, having pH 8.2 and organic carbon 0.38 per cent. The experiment was laid in split plot design with three replications. There were five foliar treatments of growth retardants (GR), i.e. control (no spray), pix -50 ppm, pix -100 ppm, cycocel -50 ppm and cycocel-100 ppm, as main plots, and two cotton genotypes (LHH 144 and F 1861) and number of spray (1 and 2) as sub plots. The active ingredient of pix is 1, 1-dimethylpiperidinium chloride and CCC is chloro choline chloride. The foliar application of GR was given at 90 days after sowing (DAS) for single spray treatment, while at 90 and 120 DAS growth stage for double spray treatments. After harvest of cotton, wheat (PBW 343) was timely sown at recommended spacing. Recommended plant protection measures were adopted in cotton. Observations on various morpho-physiological parameters *viz*. plant height, biomass, leaf area, boll number, photosynthesis and transpiration were recorded at 100 and 130 DAS. Plant samples were randomly collected from 1.0 m^2 and 1.2 m^2 land area for variety and hybrid, respectively in each plot for biomass, leaf area and plant height. Plant samples were oven dried at 70°C till constant weight. Leaf area was measured using automatic leaf area meter (Model, LI-COR 3100), while photosynthesis and transpiration were measured in fully expanded topmost third leaf using Portable Photosynthetic System (Model, LI-COR 6400). Specific leaf weight was calculated following Gardner *et al*. (1985). Chlorophyll content was measured following Barnes *et al*. (1992). Boll weight, harvest index (HI) and seed-cotton yield were recorded at maturity. Pooled analysis of three years was carried out using Windowstat (version 10.0) software package for statistical analysis.

RESULTS AND DISCUSSION

Five foliar treatments of growth retardants (GR), i.e. control (no spray), pix -50 ppm, pix -100 ppm, cycocel -50 ppm and cycocel-100 ppm, were applied on LHH 144 and F 1861 cotton genotypes at 90 and 120 DAS growth stage. Application of GR (pix, 50 and 100 ppm and cycocel, 50 and 100 ppm) significantly reduced vegetative growth i.e. leaf area (20-25%) and plant height (9-17%) in both the genotypes of cotton (Table 1). Reduction in biomass (11-12%) was also observed. On the other hand, growth retardants application significantly increased boll weight (5-16%) and seed-cotton yield (4-9%), (Table 2). Increase in number of bolls / plant (5-14%) was also observed. Harvest index also increased (8-12%) with the application of growth retardants (Table 3). This was reflected in significant increase of seed-cotton yield with the application of pix 50 ppm (2.4 t ha^{-1}). Seed-cotton yield, boll weight and harvest index of LHH 144 were significantly higher (4.5%, 15.8% and 17%, respectively) as compared to F 1861. This was largely due to higher boll weight (4.4 g $boll^{-1}$) observed in this genotype (Table

Table 1. Effect of foliar application of growth retardants on vegetative growth of cotton cultivars (pooled mean of three years)

Treatment	Plant height (cm $plant^{-1}$)					Leaf area index				
	LHH-144		F-1861			LHH-144		F-1861		
	1 Spray	2 Spray	1 Spray	2 Spray	Mean	1 Spray	2 Spray	1 Spray	2 Spray	Mean
Control (no spray)	181.0	185.3	184.0	195.7	186.5	4.47	4.47	6.90	6.07	5.48
Pix 50 ppm	168.0	153.3	170.7	163.3	163.8	3.47	3.50	5.13	4.80	4.23
Pix 100 ppm	168.7	162.7	174.0	148.7	163.5	3.67	3.63	5.43	4.80	4.38
Cycocel 50 ppm	168.0	142.3	157.3	149.0	154.2	3.37	4.07	5.03	5.47	4.48
Cycocel 100 ppm	173.3	165.0	171.7	169.0	169.8	3.00	3.50	4.80	5.03	4.08
Mean	171.8	161.7	171.5	165.1		3.59	3.83	5.46	5.23	
	GR	Var	Spray			GR	Var	Spray		
CD (P=0.05)	6.68	NS	2.93			0.20	0.12	NS		
	GRxV	GRxS	VxS			GRxV	GRxS	VxS		
CD (P=0.05)	6.24	6.24	NS			8.28	0.28	0.18		

Table 2. Effect of foliar application of growth retardants on yield attributes of cotton cultivars (pooled mean of three years)

Treatment	Seed-cotton yield (t ha^{-1})					Boll weight (g boll^{-1})				
	LHH-144		F-1861			LHH-144		F-1861		
	1 Spray	2 Spray	1 Spray	2 Spray	Mean	1 Spray	2 Spray	1 Spray	2 Spray	Mean
Control (no spray)	2.37	2.27	2.17	2.17	2.24	3.77	4.03	3.77	3.60	3.79
Pix 50 ppm	2.57	2.23	2.47	2.13	2.35	4.67	4.57	4.03	4.23	4.38
Pix 100 ppm	2.40	2.33	2.30	2.20	2.31	4.23	4.50	3.57	3.73	4.01
Cycocel 50 ppm	2.40	2.33	2.27	2.10	2.28	4.80	4.43	3.60	3.57	4.10
Cycocel 100 ppm	2.20	2.23	2.13	2.20	2.19	4.37	4.27	3.83	3.73	4.05
Mean	2.39	2.28	2.27	2.16		4.37	4.36	3.76	3.77	
	GR	Var	Spray			GR	Var	Spray		
CD (P=0.05)	0.10	0.07	0.07			0.17	0.11	NS		
	GRxV	GRxS	VxS			GRxV	GRxS	VxS		
CD (P=0.05)	NS	0.148	NS			0.25	NS	NS		

Table 3. Effect of foliar application of growth retardants on harvest index of cotton cultivars (pooled mean of three years)

Treatment	Harvest index (%)				
	LHH-144		F-1861		
	1 Spray	2 Spray	1 Spray	2 Spray	Mean
Control (no spray)	27.8	28.6	16.4	17.1	22.5
Pix 50 ppm	31.7	30.9	19.0	18.8	25.1
Pix 100 ppm	30.2	31.0	18.1	19.6	24.7
Cycocel 50 ppm	30.1	30.4	17.6	18.5	24.1
Cycocel 100 ppm	28.9	32.4	16.9	18.6	24.2
Mean	29.7	30.7	17.6	18.5	
	GR	Var	Spray		
CD (P=0.05)	0.96	0.86	NS		
	GRxV	GRxS	VxS		
CD (P=0.05)	NS	NS	NS		

2). The interaction effects of growth retardant x varieties x number of spray were not significant for all the parameters. Zhao and Oosterhuis (2000) observed increase in the fraction of fruit dry matter in total dry matter with pix plus application in cotton. Buttar and Aggrawal (2004) have also reported reduction in vegetative growth (biomass, leaf area and plant height), increase in numbers of bolls/plant and yield of cotton with growth retardants like pix, cycocel and Alar etc. Significant variations were also observed in biomass, plant height, boll numbers and seed-cotton yield due to number of spray and genotype. Biomass, number of bolls, plant height and seed-cotton yield were significantly reduced with two sprays of growth retardants (5.0, 4.0, 5.0 and 5.0%, respectively). Deol and Brar (2003) also reported reduction in vegetative growth (plant height) and yield of cotton with two spray of Mepiquat Chloride (pix), largely due to reduction in number of sympodial branches.

Variation in physiological parameters was also observed with the application of different growth regulators (Fig. 1). Application of pix (50 and 100 ppm) and cycocel (50 ppm) increased rate of photosynthesis (20-22%) and total chlorophyll content (29-69%) in both the cotton genotypes. Application of GR (both pix and cycocel) reduced leaf area and increased specific leaf weight (SLW) (70-80%) and photosynthetic radiation use efficiency (11-17%) in both the genotypes (Fig. 1). Lower LAI due to smaller leaves also allows light (PAR) to penetrate the lower canopy resulting in efficient harvesting of solar energy and better boll development (Kler *et al.* 1989), this along with the increased chlorophyll content increased leaf photosynthesis (Fig.

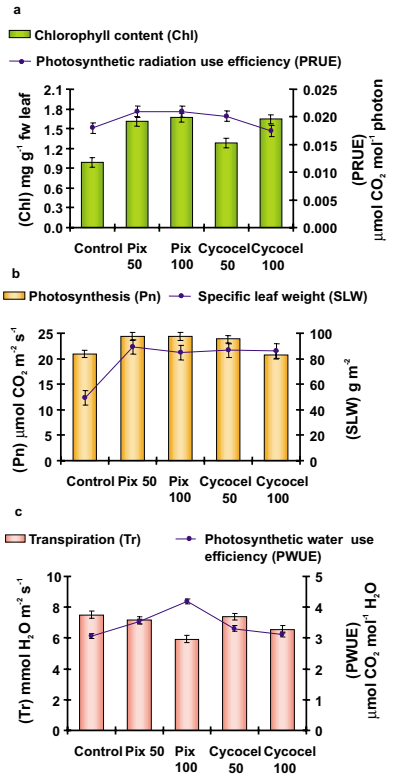

Fig. 1. Effect of pix and cycocel on (a) chlorophyll content and photosynthetic radiation use efficiency, (b) photosynthesis and specific leaf weight and (c) transpiration and photosynthetic water use efficiency in cotton

1). Kumar *et al.* (2004) also observed increase in leaf chlorophyll content and SLW with mepiquat chloride and Cycocel application in cotton. Singh and Sahay (1989) reported increase in photosynthesis with pix in cotton. On the other hand, transpiration reduced (9-13%) with the application of growth retardants. This could help the plant to maintain proper water balance resulting in high photosynthetic water use efficiency (PWUE, 15-32%) and photosynthetic radiation use efficiency (PRUE, 22%) as also reported by Singh and Sahay (1989).

The subsequent crop of wheat after cotton did not show significant variations in growth and yield. Variations in wheat equivalent yield (WEY) due to growth retardants and varieties were not significant (Table 4). Similarly, the interaction effects of growth retardant x varieties x number of spray were not significant. However, significant reduction in WEY was observed with number of spray. Two sprays of growth retardants significantly reduced the WEY (5%). On the other hand, significant variations in net returns of the cotton-wheat system were recorded with the application of growth retardants in cotton, varieties and number of spray (Table 4). Application of pix 50 ppm in cotton significantly increased net returns (6%) of cotton-wheat system. Two numbers of spray of growth retardants in

Table 4. Effect of foliar application of growth retardants on wheat equivalent yield and net return of cotton-wheat system (pooled mean of three years)

Treatment	Wheat equivalent yield (t ha^{-1})					Net returns (Rs. ha^{-1})				
	LHH-144		F-1861			LHH-144		F-1861		
	1 Spray	2 Spray	1 Spray	2 Spray	Mean	1 Spray	2 Spray	1 Spray	2 Spray	Mean
Control (no spray)	11.8	10.8	11.3	11.0	11.2	62259	51156	56060	52078	55388
Pix 50 ppm	11.6	10.7	11.6	10.6	11.1	63967	56624	60639	53325	58639
Pix 100 ppm	11.3	11.0	11.2	11.0	11.1	60085	55032	58446	52872	56609
Cycocel 50 ppm	11.4	11.1	11.2	10.7	11.1	61490	53739	60056	50846	56533
Cycocel 100 ppm	10.9	10.6	11.1	10.8	10.9	59502	49503	56899	52325	54557
Mean	11.4	10.8	11.3	10.8		61461	53211	58420	52289	
	GR	Var	Spray			GR	Var	Spray		
CD (P=0.05)	NS	NS	0.26			1598	1736	1680		
	GRxV	GRxS	VxS			GRxV	GRxS	VxS		
CD (P=0.05)	0.45	NS	NS			NS	NS	NS		

cotton at 90 and 120 DAS significantly reduced the biomass, number of bolls, plant height, seed-cotton yield, as also reported by Buttar and Aggrawal (2004). This led to reduction in the wheat equivalent yield (5%) and net returns (12%) of cotton-wheat system.

It is revealed that application of pix (50 ppm) in cotton at 90 DAS reduced excessive vegetative growth (biomass 11-12%, leaf area 20-25% and plant height 9-17 %) and increased the reproductive growth (number of bolls 5-14%, boll weight 5-16%, harvest index 8-12% and seed-cotton yield 9%). Pix (50 and 100 ppm) increased the leaf thickness in terms of specific leaf weight (70-80%), photosynthesis (20-22%), photosynthetic radiation use efficiency (22%) and photosynthetic water use efficiency (15-32%). Application of growth retardant (pix) is, therefore, useful in controlling excessive vegetative growth and enhancing the yield of cotton under irrigated conditions.

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